

## CULTIVATION OF PLANTS

THIS INVENTION relates to cultivation of plants. In particular, it relates to a ground cover for cultivation of plants and to a method of providing anchoring formations for plants.

5           According to one aspect of the invention, there is provided a ground cover for cultivation of plants, the ground cover including  
a membrane strip having a side which in use is an upper side; and  
anchoring formations on the upper side of the membrane strip for assisting a plant in the vicinity of the ground cover to anchor itself to the ground cover.

10           The membrane strip may be water impervious and it may be light impervious, at least to some degree, as required. Typically, the membrane strip is of polyethylene material. The membrane strip may be of conventional agricultural sheeting, e.g. any of the membranes or sheets supplied by Polyon Agricultural Sheeting of Kibbutz Barkai, M.P. Menashe 37860 Israel.

15           The membrane strip may have a thickness of between about 15  $\mu\text{m}$  and about 40  $\mu\text{m}$ , typically between about 15  $\mu\text{m}$  and about 37  $\mu\text{m}$ , e.g. about 20  $\mu\text{m}$ .

            The membrane strip may have a length of at least 500m, typically at least 1000 m, e.g. about 1000 m.

20           The membrane strip may have a width of between about 0.5 m and about 2.5 m, typically between about 1 m and about 1.5 m, e.g. about 1,2 m.

The anchoring formations may be defined by a net. The net may be attached, e.g. adhesively attached or physically connected such as by means of a temperature and/or pressure process when the net is also of synthetic plastics material, as described hereinafter, to the membrane strip at a plurality of spaced locations, allowing the net to be displaceable away from the membrane strip, in areas where the net is not attached to the membrane strip. Typically, the net is attached to the membrane strip along two longitudinally extending zones. Each zone may have a width of between about 2 cm and about 25 cm, typically between about 5 cm and about 15 cm, e.g. about 10 cm. Typically, the longitudinally extending zones are adjacent respective longitudinally extending edges of the membrane strip, leaving a central, longitudinally extending zone of the net displaceable away from the membrane strip.

Apertures defined by the net may be rectangular. Major sides of each rectangular aperture may extend longitudinally relative to the membrane strip.

Each aperture defined by the net may have a length of between about 2.5 cm and about 15 cm, typically between about 5 cm and about 10 cm, e.g. about 8 cm.

Each aperture defined by the net may have a width of between about 1.5 cm and about 15 cm, typically between about 2.5 cm and about 10 cm, e.g. about 8 cm.

The net may be of a synthetic plastics or polymeric material, e.g. polyethylene or polypropylene. Preferably, the net is of a material which is UV-stabilized.

The net may be of strands having a thickness of between about 0.2 mm and about 3 mm, typically between about 0.3 mm and about 0.5 mm, e.g. about 0.45 mm.

The membrane strip may define at least one aperture therethrough for receiving a plant. Thus, in use, a plant typically grows through the aperture in the membrane strip and anchors itself to the ground cover.

5 The membrane strip may define a plurality of longitudinally spaced apertures. The apertures may be equidistantly spaced and may be located on a longitudinally extending centre line of the membrane strip. Although the ground cover may be supplied in the trade with the apertures, it is to be appreciated that it may be more convenient for a user of the ground cover simply to punch or tear holes in the membrane strip in the number and locations required by the user.

10 The ground cover may be in the form of a roll, comprising a ply consisting of the membrane strip and another ply consisting of the anchoring formations.

According to another aspect of the invention, there is provided a method of providing anchoring formations for plants, the method including

15 laying a ground cover as hereinbefore described on a strip of ground; and securing the ground cover to the ground.

Laying the ground cover may include unrolling the membrane strip and the anchoring formations from a roll, comprising a ply of the membrane strip and a ply of the anchoring formations.

20 Securing the ground cover to the ground may include securing longitudinally extending zones adjacent respective longitudinally extending edges of the ground cover to the ground. This may be effected by temporarily holding down a portion of an edge on the ground and piling soil onto the held-down portion of the edge.

25 The method may include providing a tunnel or shelter over the ground cover.

According to a further aspect of the invention, there is provided a method of providing anchoring formations for plants, the method including

laying a membrane strip having a side which in use is an upper side on a strip of ground;

5       laying anchoring formations on the upper side of the membrane strip; and  
      securing the membrane strip and the anchoring formations to the ground.

The membrane strip and the anchoring formations may be laid on the ground simultaneously, and may be as hereinbefore described.

10       The method may include providing a roll, comprising a ply of the  
      membrane strip and a ply of anchoring formations, and unrolling the membrane strip  
      and the anchoring formations simultaneously to lay them simultaneously on the  
      ground.

15       Securing the membrane strip and the anchoring formations to the ground  
      may include securing longitudinally extending zones adjacent respective longitudinally  
      extending edges of the membrane strip and a body defining the anchoring formations  
      to the ground. This may be effected by temporarily holding down a portion of an edge  
      of both of the membrane strip and the anchoring formations and piling soil onto the  
      held-down portions of the edges.

20       The method may include providing a tunnel or shelter over the membrane  
      strip and the anchoring formations.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which

Figure 1 shows a three-dimensional view of a portion of a ground cover in accordance with the invention; and

25       Figure 2 shows a three-dimensional view of the portion of the ground cover of  
      Figure 1, in use.

Referring to the drawings, reference numeral 10 generally indicates a ground cover in accordance with the invention, only a portion of which is shown. The ground cover 10 includes a membrane strip 12 with a side 14 which in use is an upper side, and a net 16, the strands 18 of which define anchoring formations.

5           The net 16 is located on and covers the upper side 14 of the membrane strip 12. Two longitudinally extending, ten cm wide edge portions of the net 16 are adhesively attached to similar edge portions 17 of the membrane strip 12. Thus, a longitudinally extending central area or zone of the net 16 is not directly attached to the membrane strip 12, but only by means of the edge portions. The central area or  
10       zone is thus free to move away, at least to a limited extent, from the membrane strip 12, allowing plant tentacles to grow inbetween the net 16 and the membrane strip 12.

The membrane strip 12 is water impervious and light impervious, and is of polyethylene material. It has a thickness of about 20  $\mu\text{m}$ , a width of about 1,2 m and a length of about 1000 m.

15           Rectangular apertures or rectangular blocks 19 defined by the net 16 each has a length of about 8 cm and a width of about 8 cm. The net 16 is arranged relative to the membrane strip 12 such that the apertures or blocks 19 defined by the net 16 have their shorter sides transverse to the membrane strip 12.

20           The net 16 is of polyethylene or polypropylene material. A typical example of a suitable net 16 is a net supplied under the trade name Netlon Palnet, available from African Commerce Developing Company (Proprietary) Limited of Dacres Avenue, Epping 2, Eppingdust, Cape Town, Republic of South Africa.

25           The ground cover 10 is supplied in the form of a two-ply roll (not shown), one ply consisting of the membrane strip 12 and the other ply consisting of the net 16.

In another embodiment of the invention, instead of the edge portions of the net 16 being adhesively attached to the edge portions 17 of the membrane strip, the edge portions of the net may be physically attached to the edge portions of the membrane strip, such as by means of a high temperature and/or high pressure process e.g. by means of welding.

In use, the ground cover 10 is laid on the ground by unrolling the membrane strip 12 and the net 16 from the two-ply roll. Typically, the ground cover 10 is laid over a linearly extending ridge or hump, with a centre line of the ground cover 10 being located on a longitudinally extending centre line of the ridge or hump. Typically, an irrigation pipe or the like (not shown) is located underneath the membrane strip 12 but, as will be appreciated, the exact arrangement may depend on the kind of plants for which the ground cover 10 is intended to be used.

The ground cover 10 may be laid using a conventional machine for the laying of conventional ground covers for the cultivation of plants. Thus, the unrolling membrane strip 12 and net 16 may be temporarily held down by a pair of spaced wheels pressing down on the edge portions 17, whilst ploughshares may throw two rows 20 of soil onto the edge portions 17.

A plurality of apertures (only one of which is shown) is formed in the membrane strip 12, by simply pushing holes through the membrane strip 12. The apertures are typically located on the centre line of the membrane strip 12 and are spaced a desired distance from each other. Plants to be cultivated are then planted, one in each aperture. Typically, the ground cover 10 is used for plants with tentacles, such as watermelon or cantaloupe. The plants growing through the apertures find it easy to attach or anchor themselves to the net 16, as shown in Figure 2 of the drawings.

The use of a ground cover, comprising only a membrane strip, is known to the applicant. Membrane strip ground covers have a number of advantages,

period, and less chemical pest control is required. By also supplying anchoring formations on the upper side of the membrane strip, thereby assisting cultivated plants to anchor themselves to the ground cover 10, the ground cover 10, as illustrated, also provides the following advantages: due to the anchoring of tentacles of the plant, wind damage to the plant is reduced; plants are less acceptable to fungi, infections and stress when they are less disturbed; immature fruits are not moved about, which reduces abrasions and loss of fruit; natural wind breaks are sufficient to prevent wind damage to the plants and fruit and it is thus not necessary to erect artificial windbreaks, lowering input capital; the net 16 strengthens the membrane strip 12, inhibiting wind damage to the membrane strip 12 and thus allowing thinner membrane strips to be used and use of the ground cover 10 for a second harvest during the same season; and more mature fruit is produced per hectare, leading to higher nett income per hectare.

Some of the abovementioned advantages are illustrated by the following results from experiments conducted by the applicant.

### EXPERIMENT 1

An experiment was conducted at Ou Tuin, Doringrivier, District Clanwilliam in South Africa to investigate the effect of the invention on the cultivation of watermelon and cantaloupe compared to other ground treatment strategies. This area is subject to wind damage of plants. The watermelon variety used was Carmen and the cantaloupe variety used was Aphrodite. The membrane used with the watermelon was a brown plastics sheet, whereas the membrane used with the cantaloupe was a black plastics sheet. Observations on the leaf growth were made 8 weeks (Table 1) and 10 weeks (Table 2) after planting. The Tables show the number of fully grown permanent leaves per plant. Data for each repeat shows the average for 17 plants.

TABLE 1

	WATERMELON				CANTALOUPE			
	Repeat 1	Repeat 2	Repeat 3	Average	Repeat 1	Repeat 2	Repeat 3	Average
are ground	3.82	3.94	3.31	3.69	0.42	0.62	0.49	0.51
lastics sheet	5.29	5.23	4.38	4.97	1.52	1.64	1.65	1.60
lastics sheet + net	4.29	4.67	4.00	4.32	1.51	1.18	1.57	1.42
lastics sheet + tunnel	12.18	14.00	11.43	12.54	3.24	2.58	2.26	2.69
lastics sheet + net + tunnel	10.17	13.06	12.81	12.01	2.53	3.05	2.54	2.73

TABLE 2

	WATERMELON				CANTALOUPE			
	Repeat 1	Repeat 2	Repeat 3	Average	Repeat 1	Repeat 2	Repeat 3	Average
are ground	12.41	8.36	11.75	10.84	4.64	4.47	4.00	4.37
lastics sheet	30.12	24.94	21.94	25.67	8.50	8.73	9.13	8.79
lastics sheet + net	31.33	29.29	24.28	28.37	7.69	7.00	10.53	8.41
lastics sheet + tunnel	66.00	76.00	69.00	70.33	18.62	19.25	18.29	18.72
lastics sheet + net + tunnel	83.00	74.00	65.00	74.00	18.13	20.23	23.23	20.53

It is clear from Tables 1 and 2 that initial growth of leaves is strongest inside the tunnel and it was markedly stronger for watermelon than cantaloupe, possibly because the watermelon was established from plants, whereas the cantaloupe was established from seed. The plastics sheet, with and without the net, also had a significant effect on the number of fully grown leaves, compared to bare ground only, as shown by Tables 1 and 2. After 10 weeks, the use of a plastics sheet in combination with the net, for watermelon, showed improved results compared to the use of a plastics sheet only. It appeared that the most prominent advantage of the use of the net with the plastics sheet is not to increase the number of leaves per plant, but rather to improve the effectiveness of the leaves. This can possibly be explained by the fact that anchoring of the tentacles of the plants to the net has the effect that the leaves can maintain a fixed orientation relative to the sun in contrast with unanchored plants which are subject to continual movement by the wind, causing changes in orientation of the leaves relative to the sun. Leaves are often turned upside down so that the leaf stems have to recompensate for incorrect orientation of the leaves relative to the sun. This problem is particularly severe on smooth plastics sheets. After 10 weeks, the number of tentacles per plant anchored to the net was 8 for watermelon and 0.46 for cantaloupe. This difference can possibly again be explained by the fact that the cantaloupe was established from seed whereas the watermelon was established from plants.

Measurements were also taken to determine the effect of the different ground treatment strategies on the fruit-bearing capacity of the watermelon and the cantaloupe. The results are shown in Table 3 and indicate the number of fruits per plant after about 14 weeks. For cantaloupe, fruits larger than 8 cm were counted and for watermelon, fruits larger than 15 cm in length were counted. The values given are the average of 17 plants. Table 4 shows the results (number of fruits/plant) after about 20 weeks.

TABLE 3

	WATERMELON				CANTALOUPE			
	Repeat 1	Repeat 2	Repeat 3	Average	Repeat 1	Repeat 2	Repeat 3	Average
are ground	0.58	0.44	0.40	0.47	0.50	0.46	0.56	0.51
lastics sheet	0.82	0.41	0.53	0.59	1.88	1.60	1.94	1.81
lastics sheet + net	0.94	1.06	0.88	0.96	1.93	1.47	2.53	1.98
lastics sheet + tunnel	1.35	0.94	1.00	1.10	1.63	1.94	2.13	1.90
lastics sheet + net + tunnel	1.18	1.38	1.05	1.20	2.11	2.53	2.06	2.23

TABLE 4

	WATERMELON				CANTALOUPE			
	Repeat 1	Repeat 2	Repeat 3	Average	Repeat 1	Repeat 2	Repeat 3	Average
are ground	1.07	1.00	1.00	1.02	1.56	1.53	1.75	1.61
lastics sheet	1.06	1.06	1.00	1.04	2.31	2.29	2.38	2.33
lastics sheet + net	1.13	1.18	1.25	1.19	2.71	2.67	2.65	2.67
lastics sheet + tunnel	1.00	1.24	1.18	1.14	2.44	2.31	2.44	2.40
lastics sheet + net + tunnel	1.42	1.41	1.20	1.34	2.73	2.75	2.76	2.75

It is clear that the combination of the plastics sheet with the net has a marked effect on the fruit-bearing capacity of both watermelon and cantaloupe, particularly in combination with a tunnel, particularly when compared to bare ground.

5 Table 5 illustrates the effect of the ground treatment method on average fruit diameter (in mm) after about 20 weeks.

TABLE 5

	WATERMELON				CANTALOUPE			
	Repeat 1	Repeat 2	Repeat 3	Average	Repeat 1	Repeat 2	Repeat 3	Average
re ground	165.06	169.36	163.63	166.02	130.84	130.13	126.03	129.00
stics sheet	171.25	169.33	176.00	172.19	131.28	141.29	142.63	138.40
stics sheet + net	169.08	179.50	176.92	175.17	139.13	136.88	138.81	138.27
stics sheet + tunnel	180.08	171.76	176.20	176.01	136.20	137.50	140.75	138.15
stics sheet + net + tunnel	184.70	217.12	184.00	195.27	137.94	137.09	139.10	138.04

As can be seen, for watermelon there was enough variation in fruit size in order to, in addition to fruit-bearing capacity, affect the mass of harvested fruit. For cantaloupe, this variation was relatively small and it is thus the fruit-bearing capacity in the case of cantaloupe which will have the largest effect on the yield of the cantaloupe harvest.

The effect of the ground treatment method on harvest yield was calculated (in tons per hectare). The following factors were used in calculating yields: the number of fruits for watermelon was limited to fruits longer than 15 cm, and for cantaloupe to fruits longer than 8 cm for one trial row of 17 trial plants per planting. Average fruit diameter is calculated as the sum of the length diameter and the width diameter divided by two for 16 fruits from one representative trial row per planting. The calculated weight per fruit was determined by weighing 15 fruits over the whole range of fruit sizes and preparing a graph of the relationship of the average fruit diameter against the average fruit weight. Calculated harvest yield per hectare was then calculated as follows: number of fruits per plant after 20 weeks multiplied by the calculated average weight per fruit multiplied by 10000 plants per hectare divided by 1000, to give calculated harvest yield in ton per hectare. The results are shown in Table 6 below.

TABLE 6

	WATERMELON				CANTALOUPE			
	Average fruit diameter (mm)	Calculated fruit mass per fruit (kg)	Number of fruit per plant	Calculated harvest yield (ton/ha)	Average fruit diameter (mm)	Calculated fruit mass per fruit (kg)	Number of fruit per plant	Calculated harvest yield (ton/ha)
ground	166.02	3.79	1.02	38.66	129.00	1.22	1.61	19.64
ics sheet	172.19	4.21	1.04	43.78	138.40	1.48	2.33	34.48
ics sheet + net	175.17	4.38	1.19	52.12	138.27	1.47	2.67	39.24
ics sheet + tunnel	176.01	4.46	1.14	50.84	138.15	1.46	2.40	35.04
ics sheet + net + tunnel	195.27	6.18	1.34	82.81	138.04	1.47	2.75	40.43

It is clear from Table 6, that the use of the net with a plastics sheet (with or without the use of a tunnel), has markedly improved calculated harvest yields for both watermelon and cantaloupe, compared to bare ground and the use of a plastics sheet only. This is probably a reflection of the negative effects of wind damage in the area where the trials were conducted and the ability of the net to limit wind damage. The use of plastics sheeting alone improved calculated harvest yield for watermelon by only 13.2 %, compared to 75.6 % for cantaloupe. It is suspected that an unidentified factor in the form of a harmful organism infestation affected the watermelon covered by the plastics sheet only, causing the watermelon not to reach its full potential.

Observations were made to determine the effect of the different ground treatment strategies on the possibility of an early harvest. The results are shown in Table 7 below, which indicates the number of fruit that ripened first per trial row of 17 plants, after about 20 weeks.

TABLE 7

	WATERMELON				CANTALOUPE			
	Repeat 1	Repeat 2	Repeat 3	Average	Repeat 1	Repeat 2	Repeat 3	Average
ground	4	3	1	2.7	0	0	0	0.0
tics sheet	8	6	8	7.3	0	0	0	0.0
tics sheet + net	9	15	8	10.7	0	0	0	0.0
tics sheet + tunnel	12	15	12	13.0	2	1	2	1.7
tics sheet + net + tunnel	21	19	13	17.7	2	4	1	2.3

The improvement when using plastics sheet combined with a net in respect of watermelon is very clear from Table 7. For cantaloupe, the improvement is also marked when a plastics sheet, a net and a tunnel are used, compared to bare ground. It was also observed that surface damage of young fruit as a result of movement caused by wind was at least 50 % higher for those ground treatments strategies which did not include a net, for both watermelon and cantaloupe.

**EXPERIMENT 2**

An experiment was conducted to determine the effect of the colour of the plastics sheet on the growth rate of watermelon and cantaloupe. Measurements of the number of fully grown permanent leaves in one row of 30 plants were taken after 8 weeks and 10 weeks. Each planting consisted of 100 plants. The results are shown in the following Table 8.

**TABLE 8**

	<i><b>WATERMELON</b></i>		<i><b>CANTALOUPE</b></i>	
	<b>8 weeks</b>	<b>10 weeks</b>	<b>8 weeks</b>	<b>10 weeks</b>
Black plastics sheet	4.03	18.67	1.36	7.13
Brown plastics sheet	4.42	22.19	1.74	9.07

It is clear that, after 10 weeks, stronger stimulation of growth occurred underneath the brown plastics sheet than the black plastics sheet for both watermelon and cantaloupe. At this stage, there were 18.9 % more fully grown leaves under the brown plastics sheet for watermelon and 27.2 % more fully grown leaves for the cantaloupe.

The effect of the colour of the plastics sheet on calculated harvest yield was calculated. Calculations were done on the same basis as for Table 6, although fruit size measurements were taken for 100 plants for both watermelon and cantaloupe. The results are reflected below in Table 9.

TABLE 9

	WATERMELON				CANTALOUPE			
	Number of fruit per plant (8 weeks)	Number of fruit per plant (20 weeks)	Calculated fruit mass per fruit (kg)	Calculated harvest yield (ton/ha)	Number of fruit per plant (8 weeks)	Number of fruit per plant (20 weeks)	Calculated fruit mass per fruit (kg)	Calculated harvest yield (ton/ha)
Black plastics sheet	----	----	----	----	0.96	1.57	1.35	21.20
Brown plastics sheet	----	----	----	----	1.21	2.15	1.41	30.32
Black plastics sheet	0.91	1.08	6.44	69.55	----	----	----	----
Brown plastics sheet	1.08	1.34	6.47	86.70	1.97	2.42	1.54	37.26

**EXPERIMENT 3**

The purpose of this experiment was to determine the effect of the ground treatment strategies on sand blasting damage of young plants of Honey Chow cantaloupe cultivar. The plants were planted in such a manner that from repeat 1 to repeat 3 the plants were progressively more exposed to wind blown sand. This effect was promoted by judicious use of a reed windbreak. The following Table 10 illustrates the results 3 weeks and 5 weeks after planting.

**TABLE 10**

	<i>Percentage surviving plants in planting</i>			
	Repeat 1	Repeat 2	Repeat 3	Average
Bare ground	73.3 - 73.0	58.8 - 10.6	18.8 - 8.2	50.3 - 30.6
Brown plastics sheet	55.5 - 56.0	55.7 - 56.0	46.6 - 28.3	52.6 - 46.7
Plastics sheet + net	72.0 - 72.0	72.2 - 72.1	52.2 - 28.2	65.5 - 57.4
Average	65.2 - 65.3	64.2 - 52.4	40.8 - 22.4	56.7 - 46.6

The positive effect of the use of a plastics sheet in combination with a net is clearly illustrated in Table 10. It was further observed that, where a plastics sheet was used without a net, the wind eroded soil from the edges of the sheet with the result that the plastics sheet was torn and blown to one side, particularly in respect of repeat 3. This problem did not occur where the plastics sheet was used in combination with the net, as the wind did not erode the soil from the net allowing the net to anchor the plastics sheet.